

# PAMELA Wave Front Sensor Enhancement

**Project Number: 96-22**

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## Purpose

The primary objective of the PAMELA wave front sensor (WFS) enhancement was to augment and improve the performance of this multidiscipline system which involves control, optics, structures, and thermal (COST) interactions. The noise floor produced by the original Hartmann-Shack WFS electronics was simply too large to allow for high resolution tip/tilt control of the 0.5 m segmented primary mirror. A new WFS has been constructed and is currently being evaluated in the PAMELA facility located in Room 154 of Building 4619. NASA personnel have worked directly with Blue Line Engineering to accomplish the aforementioned objective of this Center Director's Discretionary Fund project.

## Background

The PAMELA prototype telescope was the first to have a fully adaptive primary mirror, consisting of 36 hexagonal, injection-molded, Pyrex segments which are 7 centimeters flat to flat. The segments were mounted on three long-throw, voice-coil actuators for tip/tilt, and piston motion control. The segment tilts were measured with a Hartmann-Shack wave front sensor while the piston errors between adjacent segments were measured via inductive edge sensors. The PAMELA requirements were to demonstrate the following: closed-loop edge matching control to  $\lambda/20$  ( $\lambda = 632.8$  nm) using the 36 individual active mirror segments; that the edge control could be maintained while simultaneously controlling the tip/tilt of the segments to the required precision; and that PAMELA could produce diffraction-limited images while subjected to internal and

external disturbances. Once the system was operational and control algorithm development had begun, it became apparent that the original WFS produced low-resolution high noise signals. The mirror actuators performed quite well and the mirrors simply followed the instruction provided by the control computer. However, the computer was interpreting the high noise floor as true tip/tilt signals from the WFS. The segments exhibited extreme jitter that was directly proportional to the magnitude of the noise generated at the WFS. An exhaustive effort was undertaken to improve the existing WFS performance. Only a small reduction in the noise was obtained. Thus, through CDDF funding, an improved Hartmann-Shack WFS was developed.

## Approach

The first step toward reducing the WFS noise floor was to quantify the signal characteristics produced by the inadequate WFS. Replacement candidate sensors were then selected based upon performance as well as cost. Several criteria were used to evaluate the sensors. The primary evaluation parameters were linearity, signal to noise ratio, and stability. The Hamamatsu S4349 quad cell with a noise equivalent power (NEP) of  $4.0 \times 10^{-15}$  W/Hz<sup>1/2</sup> sensor was chosen to be integrated into the new WFS. In addition, supporting electronics were designed to process the quad cell output. Blue Line Engineering was contracted to construct the new electronics package. The improved WFS arrived at MSFC on August 22, 1997. MSFC and Blue Line personnel worked together to integrate the new WFS into the PAMELA optical train.

**Accomplishments**

The final WFS design included much of the original mounting hardware. This approach lowered assembly cost and allowed for most of the funding to be committed to the sensors and supporting electronics. Integration of the WFS upgrade was completed on August 28, 1997. The new WFS represents an improvement in performance of nearly 40:1 over it predecessor and provides the necessary capabilities for deffraction limited control of the 36 mirror segments. The WFS is no longer the limiting component of the PAMELA system.

**Planned Future Work**

The next step will be to rid the optical system of interference effects so that diffraction limited performance may be obtained. Once the PAMELA system is completely operational, various control algorithms and approaches will continuously be investigated. This optical system represents an outstanding opportunity to continue MSFC’s involvement in the development and understanding of hardware that involve COST interactions. The basic problems that have to be

overcome within the PAMELA systems will be revisited as MSFC and NASA continue to investigate segmented optical systems. As with the Next Generation Space Telescope (NGST), apertures will continue to be built larger and larger. The only way to put a large aperture in space is to assemble it from segments.

**Funding Summary (\$k)**

	<b>FY96</b>	<b>FY97</b>	<b>Total</b>
Authorized FY97:	75.2	0	75.2
Obligated:	20	55.2	75.2
Unprocessed:	55.2	0	0

**Status of Investigation**

- Project approval—October 17, 1995
- Estimated completion—October, 1998 (with no cost extension)
- Request extension—1 year with no additional funds